Capturing Useful Genetic Diversity to Enhance Agricultural Production

Candice Gardner, USDA-ARS and the

North Central Regional Plant Introduction Station, Iowa State University, Ames, IA

Elmer Heyne Lecture, Kansas State University, March, 2012

NCRPIS, Ames, IA - Summertime

NCRPIS, Ames - Wintertime

Food security depends upon germplasm collections.

http://www.fao.org

In agriculture, the most important resources are soil, water, air, and germplasm collections.

Science, 1986

PGR Support Research To Meet Societal Needs

- Food
- Feed
- Fiber
- Fuel
- Functional compounds and products

Challenge: Doubling Food Production by 2050 in a Sustainable Manner

Contributions of Plant Genetic Resources

Abiotic Stress Resistance

- Drought/Flooding
- Heat tolerance
- Cold tolerance during emergence
- Winter hardiness
- Salt tolerance
- Aluminum toxicity tolerance

Biotic Stress Resistance

- Diseases
- Insect Pests
- Herbivory
- Antibiosis

Earliest Plant Introductions

- **Oldest known Plant Introduction Record:**

  Mesopotamian inscription relates that Sargon crossed over the Taurus Mountains into the heart of Asia Minor and carefully brought back specimens of trees, vines, figs, and roses to Sumeria, about 2500 B.C.

  (Wooley, C.L. 1928. The Sumerians, 79. Oxford, Clarendon Press.)

- First recorded expedition organized for collecting plants: Queen Hatshepsut of Egypt sent ships to the Land of Punt to get the incense tree about 1500 B.C.

- In the village of Fukushoji, in the province of Kii, Japan, a monument to Tajima Mori states ‘How magnificent is the result of Taji’s work.’ He went to China 1800 years ago on imperial orders to study and bring back citrus fruits to Japan.

Ryerson, K.A. 1933. History and Significance of the Foreign Plant Introduction Work of the United States Department of Agriculture. Agricultural History, Vol. 7, No. 3 (Jul., 1933), pp. 110-128 .

Threats to Global Food Production

- Insect and Disease Pests
  - Wheat Stem Rust Re-emerges
- Fertility Costs and Availability
- Energy Costs
- Water
- Stable Supply of Adapted Cultivars
- Land Use / Land Loss
- Climate change
- Politics

Growing global energy needs coupled with the increasing demands for food and other plant-based resources have highlighted the critical importance of PGR now more than ever.

Demand for well-documented PGR increases annually.

Brief Outline

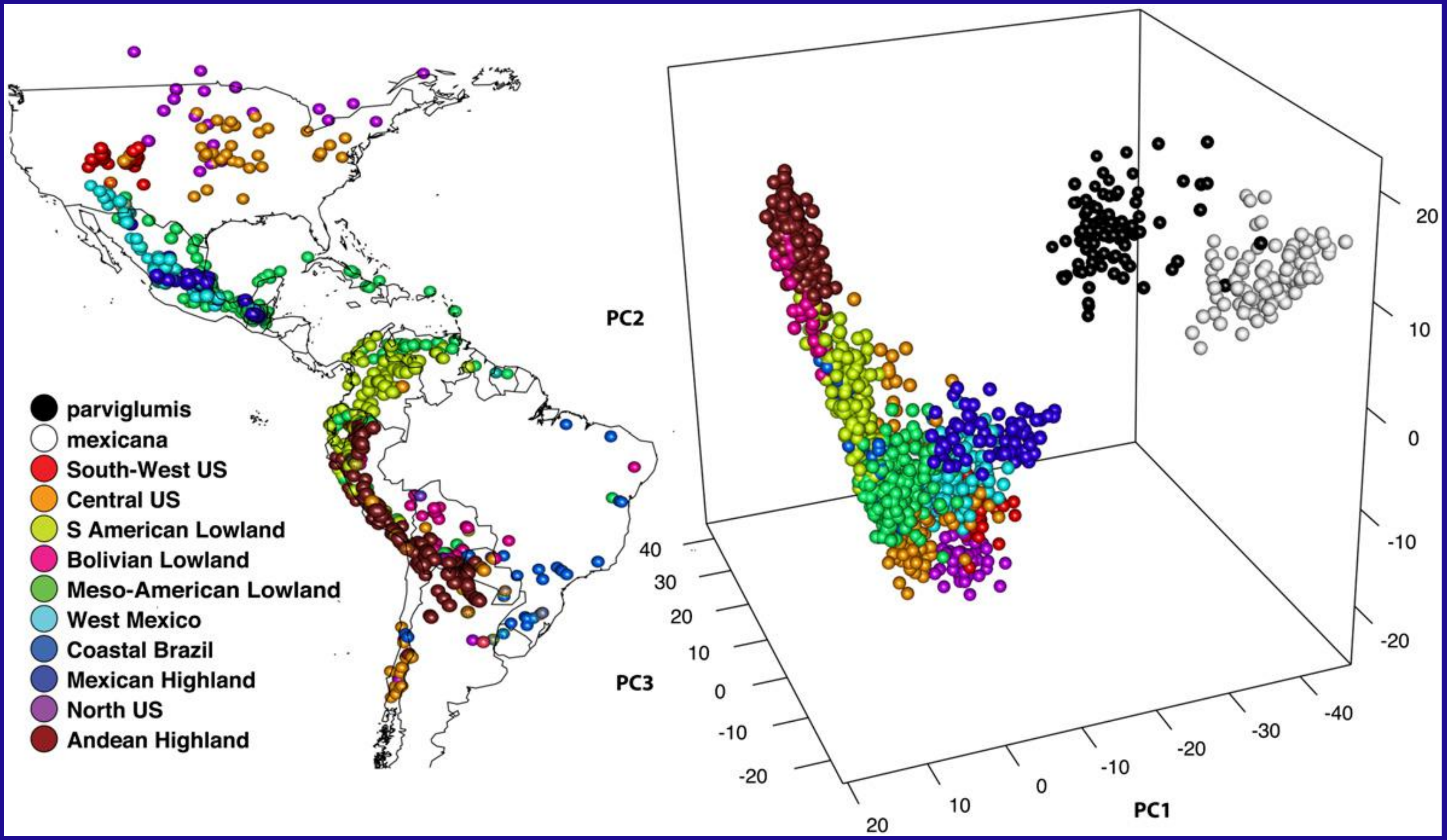
- Sources of diverse maize germplasm & collection status
- Historical examples of capture of useful diversity & traits from targeted germplasm & challenges
- Technology advances
    - Information systems
    - Intelligent phenotyping
    - Diverse germplasm →P+G→ Discovery
    - Applications
- Opportunities

Histoire Naturelle des Indes (1586-1600)
known as
The Drake Manuscript: Horticulture and History
Garden scene in *The Drake Manuscript (f.121)*
Courtesy of Jules Janick, Purdue University

Zea mays **ssp.** ***parviglumis*** **plants growing in a ravine near Teloloapan in the Balsas river drainage, Guererro, Mexico and ears of teosinte and of maize**

Courtesy of the Doebley lab website

Photos by Hugh Iltis



Map of sampled maize accessions (colored by genetic group) and first three genetic PCs of all sampled accessions.
From van Heerwaarden et.al, 2011.

The World’s #1 Crop - 91 M U.S. Acres


Peru,
2008

The Other Members of the Top 10 World Crops

- Wheat
- Rice
- Potatoes
- Cassava
- Soybean
- Sweet Potatoes
- Sorghum
- Yams
- Plantains

Current Status: Plant Genetic Resources

- An estimated 6 million samples in 1500 genebanks world-wide; of these, 1.5 million are probably unique.
- About 10% of the samples are held by the IARCs.
- Most samples are in genebanks controlled by national governments.
- Large national genebanks in the U.S., Canada, Australia, Japan, S. Korea, India, China, Brazil, Russia, Germany, South Africa.
- Public gardens, NGOs, universities, and companies also hold thousands of samples.

U.S. National Plant Germplasm System (NPGS)

A co-operative effort by public and private organizations to preserve diverse plant genetic resources through:

germplasm acquisition

preservation

evaluation

documentation

distribution to facilitate utilization

enhancement

Contributing to long term security of U.S. and world food supplies.

National Program 301: Plant Genetic Resources, Genomics and Genetic Improvement

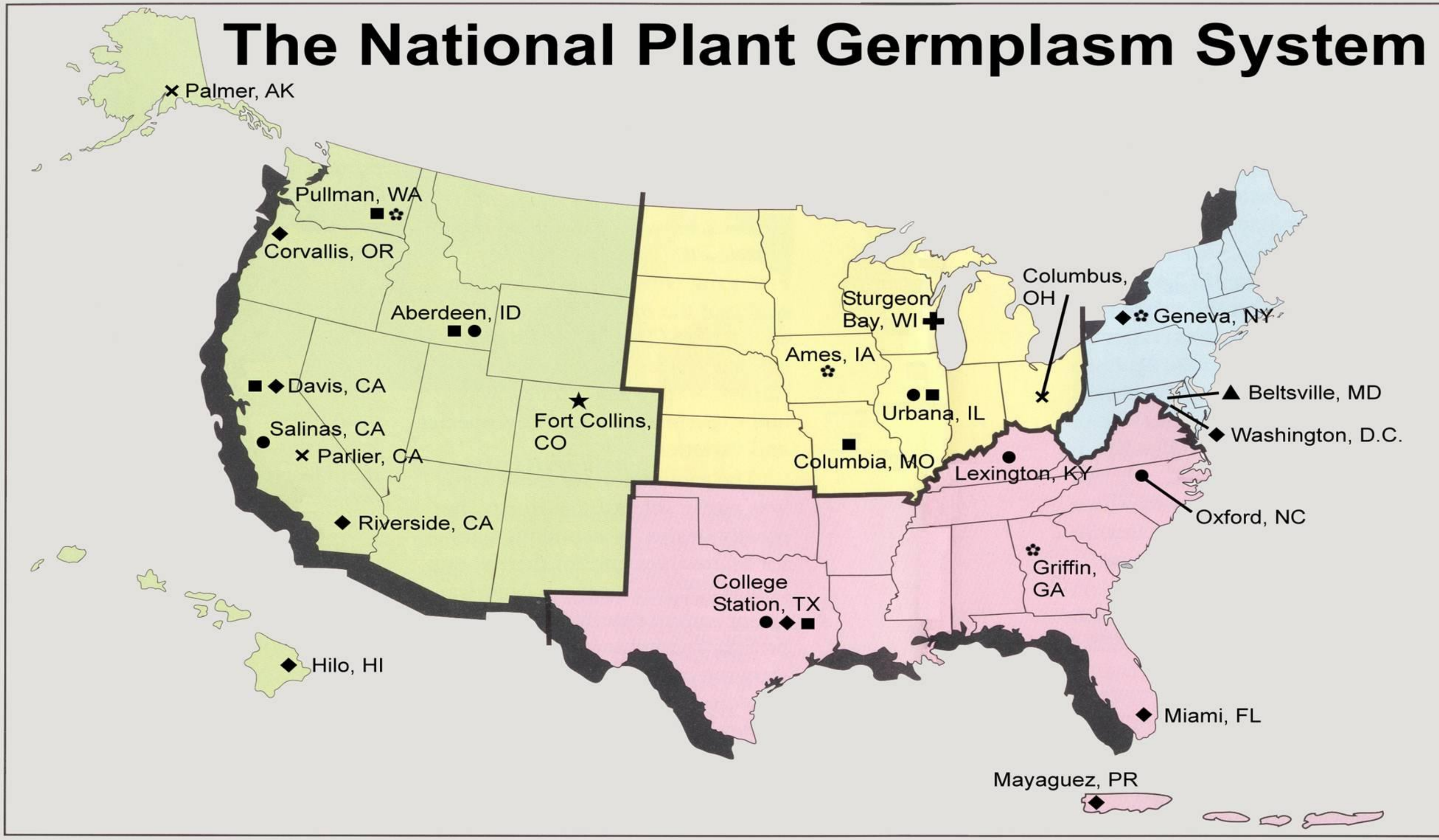
Vision Statement -

Furnishing genetic, genomic, and bioinformatic tools, information, and genetic resources to enhance American agricultural productivity and ensure a high quality, safe supply of food, fiber, feed, ornamentals, and industrial products

Mission Statement -

To safeguard and utilize plant genetic resources (genetic raw material), associated genetic and genomic databases, and bioinformatic tools to ensure an abundant, safe, and inexpensive supply of food, feed, fiber, ornamentals, and industrial products for the United States and other nations.

The National Plant Germplasm System



- ✿ Regional Plant Introduction Station
- ● Crop-specific seed collection
- ■ Crop-specific genetic stocks collection
- ◆ National Clonal Germplasm Repository
- ★ National Seed Storage Laboratory, Fort Collins, Colorado
- ✚ National Potato Introduction Station, Sturgeon Bay, Wisconsin
- ▲ National Germplasm Resources Laboratory, National Plant Germplasm Quarantine Center, Beltsville, Maryland
- × Developing Site

The U.S. National Plant Germplasm System (NPGS)

- “Base collection”; preservation research.
- GRIN database: www.ars-grin.gov
- Acquisition via plant exploration and exchange .
- Germplasm quarantine activities now part of APHIS; ARS conducts related research.
- ~~26~~ 25 active US sites manage clonally and seed-propagated collections.
- Conduct associated research.
- Crop Germplasm Committees; university, NGO, industry cooperators, and ARS.

National Plant Germplasm System

Types of germplasm

- Wild crop relatives
- Landrace collections
- Genetic stocks
- Domestic breeding lines
- Heirloom accessions
- Cultivars
- Plant mycosymbionts

Collection Holdings and Their Classification

Life Forms

- Annual
- Biennial
- Perennial
- Perennial Root
- Spring
- Winter
- Half Winter
- Intermediate

Improvement Status

- Wild
- Weedy
- Landrace
- Improved Population
- Cultivar
- Clonal Material
- Inbred
- Unknown

US NPGS System Holdings

- 25 Active Sites + the NCGRP (Ft. Collins) + the NGRL (Beltsville)
- 31 Designated Collections
- 547,647 Accessions as of March 27, 2012
- 20-25% of Accessions Distributed Yearly
- 2,223 Genera; range of 1-583 per site
- 13,466 Species; range of 1-3,058 per site
- 223 Families Represented
- Info available at http://www.ars-grin.gov

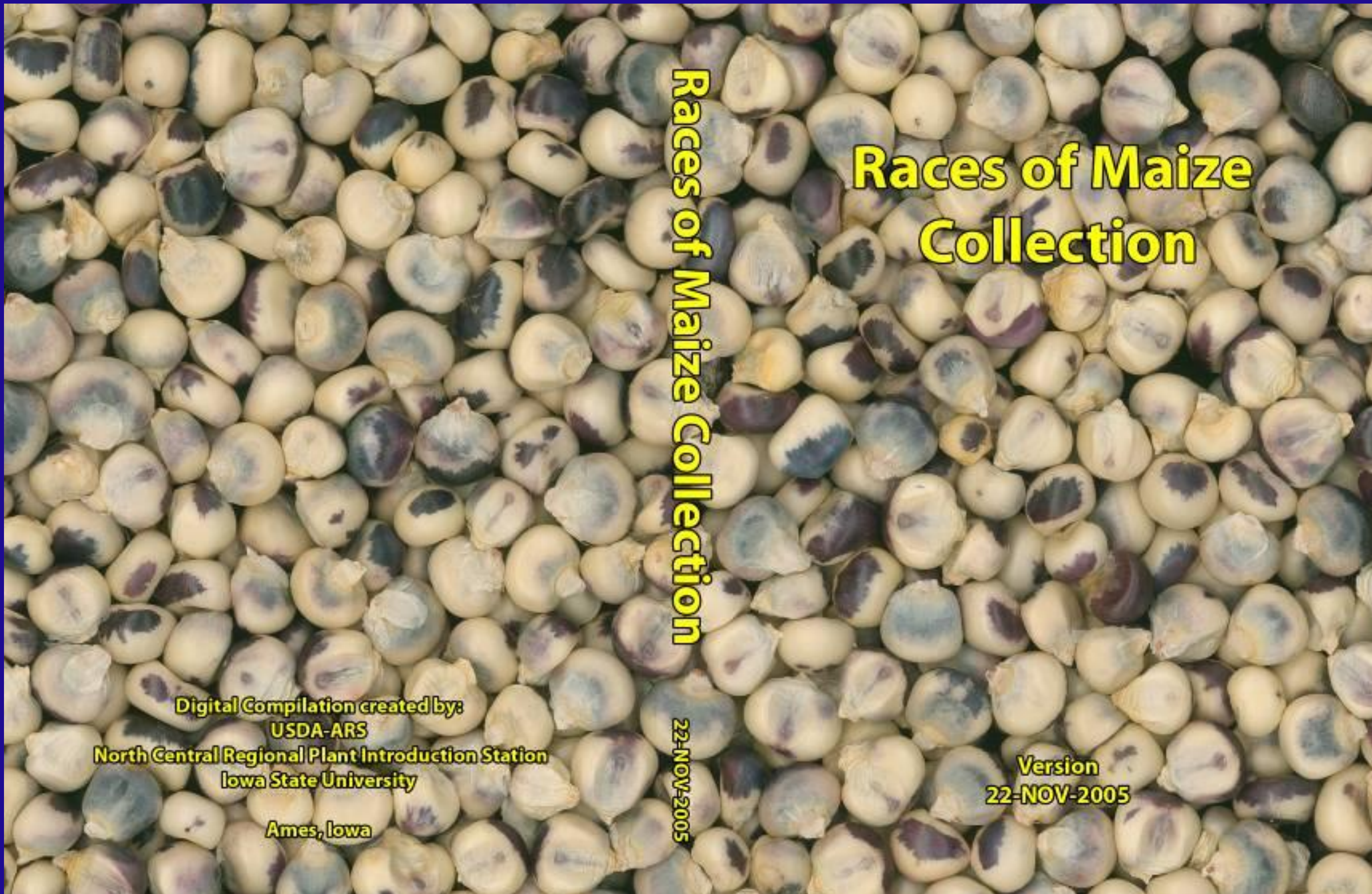
Researchers frequently need….

- Linked genomic and phenotypic information
- Ability to determine value of alleles, including cryptic alleles, haplotypes
- Access to standardized information
- Access to descendant germplasm populations

Plant Germplasm Accessions by NPGS Site *

Genebank Site	Count	% of NPGS Holdings	% of NPGS Distributions**	Avg Annual Distributions**
National Small Grains Collection	139,941	26	24.4	36,626
Plant Genetic Resources Conservation Unit, Griffin, GA	91,843	17	17.7	26,508
Western Regional PI Station	89,144	16	16.4	24,687
North Central Regional PI Station	**51,576**	**9**	**16.7**	**25,005**
Total – 4 Sites	**380,014**	**69**	**75.2**	**112,826**
Total - All NPGS Sites (20)	**543,863**	**100**	**100**	150,095
*** November, 2011 data – excludes genetic stocks data**				
**** 2005 - 2010 Data**				
Genebank Site	**Count**	**% of NPGS Holdings**	**% of NPGS Distributions****	**Avg Annual Distributions****
Maize Genetic Stock Center	**7,510**	**1**	**58.7**	**10, 186**

Although the NCRPIS holds about 9% of NPGS accessions, it accounts for 16.7% of annual distributions.

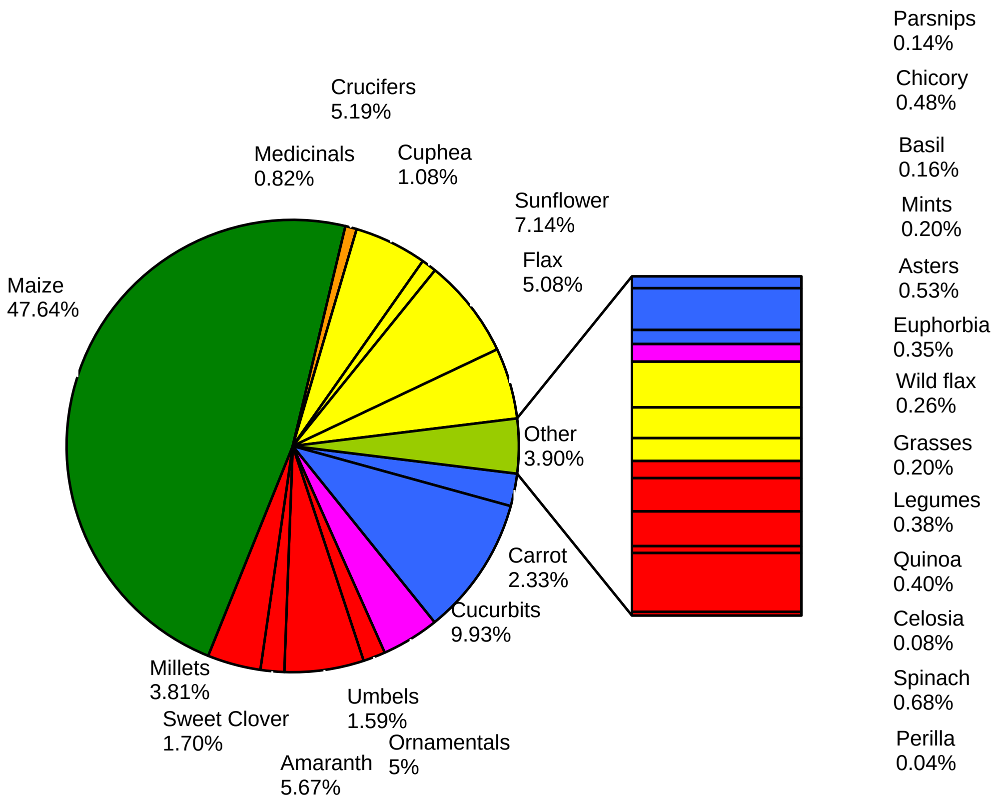

Races of Maize Collection
Races of Maize Collection
22-NOV-2005
Digital Compilation created by:
USDA-ARS
North Central Regional Plant Introduction Station
Iowa State University
Ames, Iowa
Version
22-NOV-2005

North Central Regional Plant Introduction Station and Plant Introduction Research Unit Mission

Our mission is to conserve genetically-diverse crop germplasm and associated information, conduct germplasm-related research, and encourage the use of germplasm and associated information for research, crop improvement and product development.

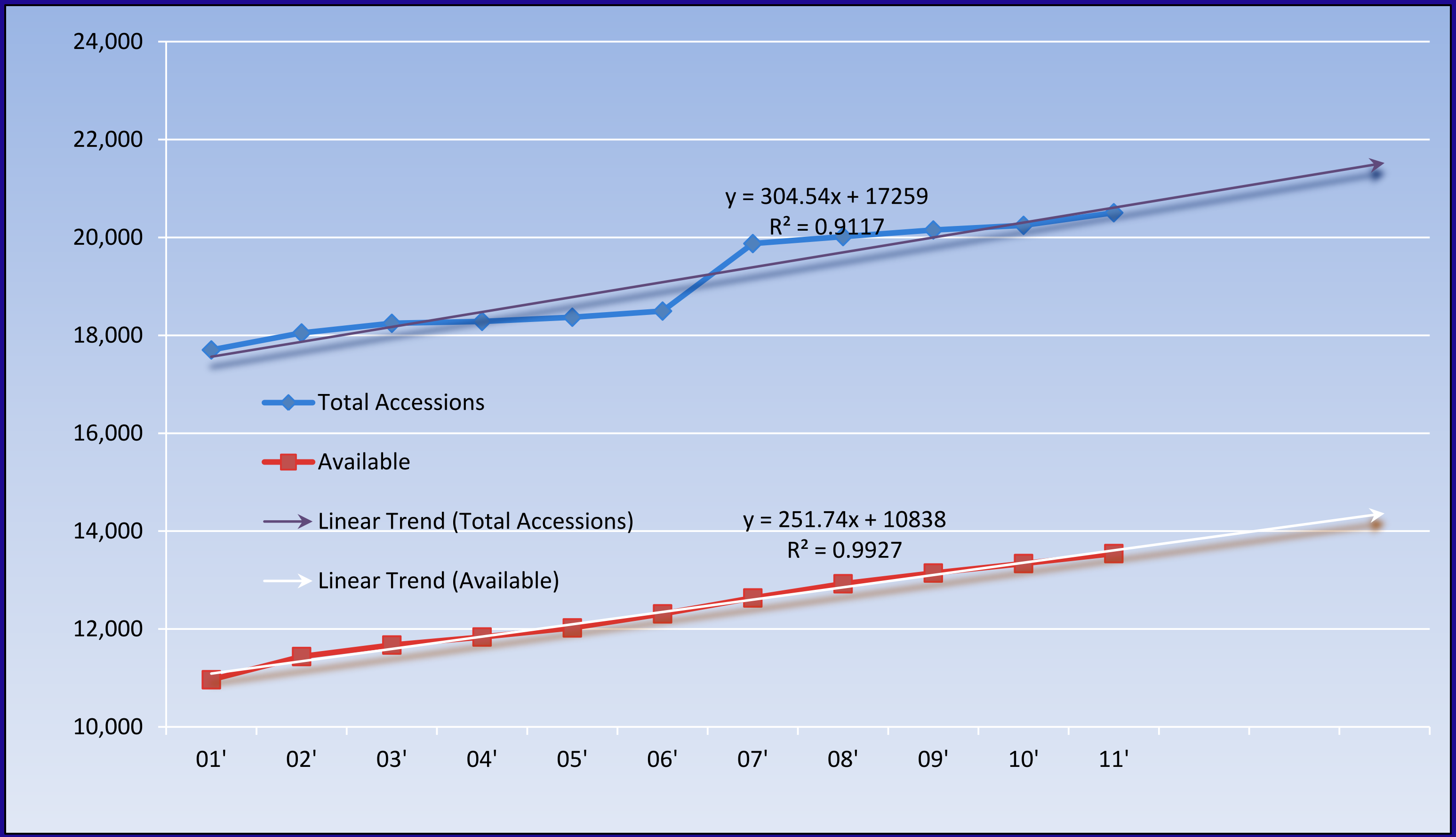
Our focus in Ames is primarily heterogeneous, heterozygous, outcrossing crops.

NCRPIS Holdings – March, 2012
51,646 Accessions – 1,925 Taxa

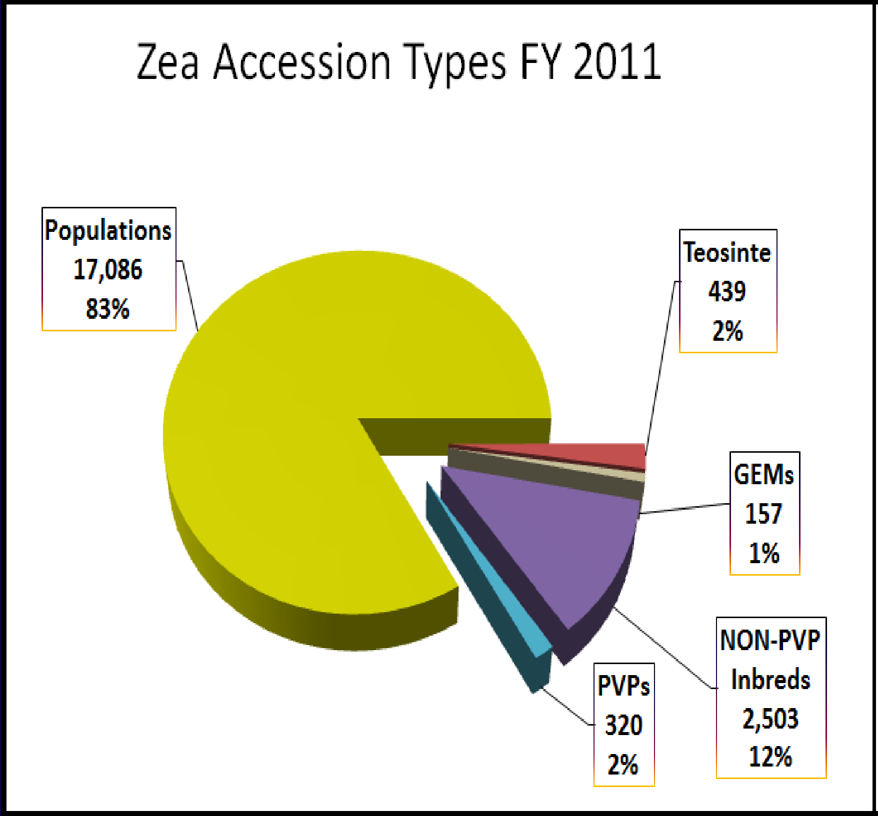


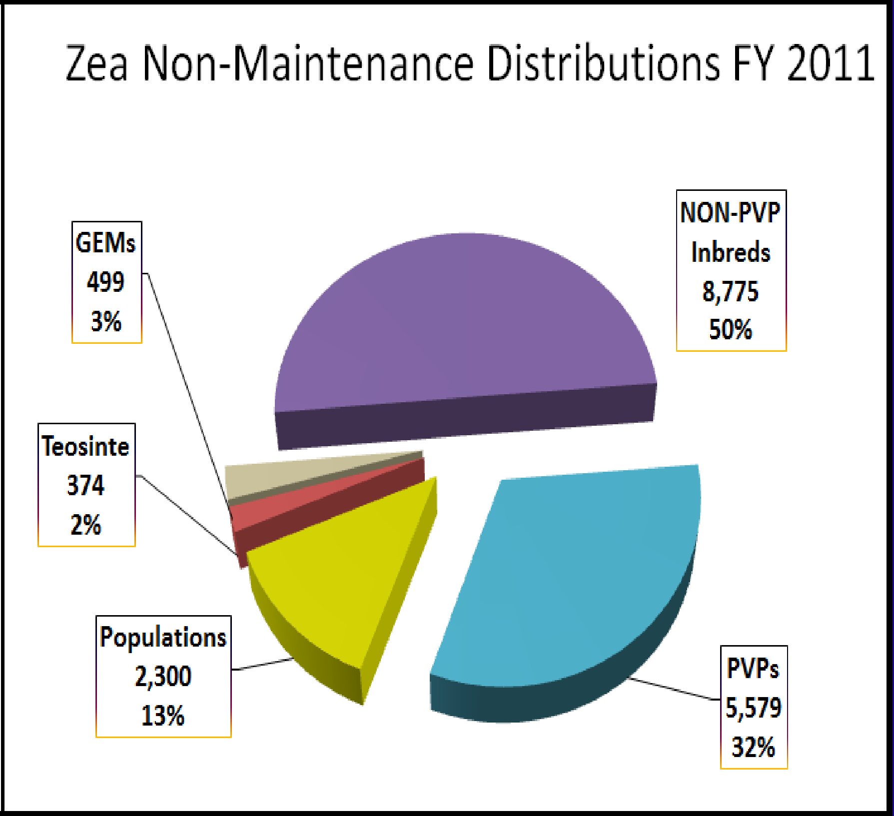
Diverse Maize Germplasm Resources

- Germplasm Collections
- Crop Science Registered Lines
- Licensed Lines
- International and National Breeding Programs, Private and Public Sectors



Maize Collection Holdings and Availability
October 1, 2011 Status

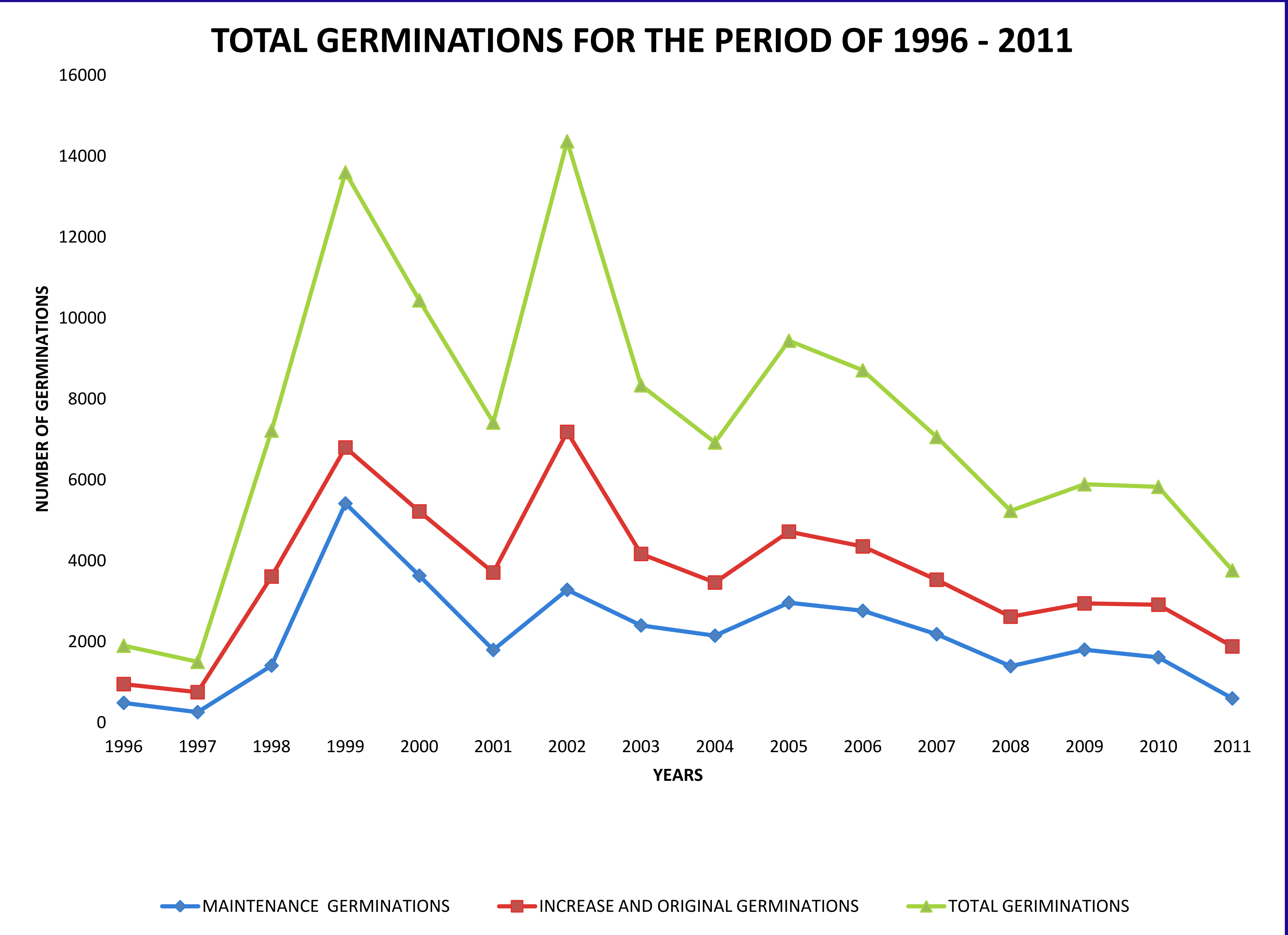




Comparison of Collection and Distribution Groups

Year	Total Packets Distributed	Total Accessions Distributed	Orders Processed	Individual Cooperators
FY ’07	2,879	130	207	104
FY ’08	2,645	141	161	104
FY ’09	3,883	186	250	132
FY ‘10	4,858	224	245	139
FY ’11	5,579	267	249	155

Demand for Expired PVP Lines


TOTAL GERMINATIONS FOR THE PERIOD OF 1996 - 2011
16000
14000
12000
10000
8000
6000
4000
2000
0
NUMBER OF GERMINATIONS
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
YEARS
MAINTENANCE GERMINATIONS
INCREASE AND ORIGINAL GERMINATIONS
TOTAL GERIMINATIONS


Sunflowers in Kansas
Modern intensive agriculture relies upon genetic uniformity

Wild *Helianthus* Collection in California

The wild (annual and perennial) and cultivated Helianthus species collection is heavily utilized for disease and insect resistance, oil and/or confectionary use properties, and bioenergy applications. The Helianthus genome is being sequenced, and mapping populations generated by Fargo, ND researchers and collaborators.

Daucus carota **diversity**

USDA-ARS taxonomist David Spooner, geneticist Phil Simon, and ISU Curator Kathy Reitsma are working to complete characterization of *Daucus* and allied species for morphological traits, genetic marker analysis, and will complete a taxonomic revision.

Young *Daucus aureus* seedlings – this accession was collected pre-1964 in Israel

Helianthus seedlings for Parlier, CA regeneration

ISU Oilseeds Curator Laura Marek

H. niveus* ssp. *tephrodes

PI 500428 – unidentified wild *Cucumis* sp. from Zambia

Conserving Ash Tree Germplasm for Future Re-establishment

Ash trees are one of our most popular landscaping ornamentals, making up approximately one-third of urban trees in the Midwest. Ash trees are threatened by the Emerald Ash Borer. Since this pest's discovery in the U. S. in 2002, its larvae have killed more than 20 million ash trees here. Scientists and staff of the North Central Regional Plant Introduction Station, where the ash collection is conserved, are part of a national effort to gather and protect ash germplasm so that when scientists find a solution to the problem, they will be able to rebuild the population from a foundation of genetic diversity.

Maintenance and Regeneration

Objective: provide viable, high quality seed and plant materials which are true to the original genetic profile.

- Controlled pollination is necessary for cross-pollinated crops, and is accomplished by hand- or insect-mediated methods.

- Clonal and micropropagation methods require controlled conditions for the production of pathogen-free propagules

ALL CONTAMINATION IS BAD, REGARDLESS OF THE SOURCE

Amaranthus tents in Ames, IA


Pollinator insect colonies in Ames, IA


23

Seed Storage at the NCRPIS, Ames, IA

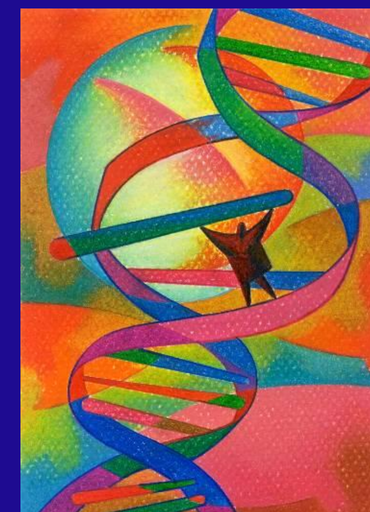
NPGS Genetic Resources Flow

Accession in genebank

Morphological data

GRIN

Passport
Data, GIS



Phenotypic data

Disease

Nutrition

Yield components

Images

Genotypic data

Accession Utilization

C. Coyne, Pullman, WA

Genebank Information Databases

A major function of a genebank is to manage the information associated with collections and provide them in a usable format, in order to manage the collection and to facilitate utilization.

Examples of germplasm information databases would include GRIN, SINGER, EURISCO, and ICIS among others.

GRIN and GRIN-Global

- Germplasm Resource Information Network – 1985
- GRIN-Global System – designed to succeed GRIN and provide a license-free, database flexible, multi-lingual interface for the world's genebanks
  - A development partnership between the USDA-ARS, the Global Crop Diversity Trust and Bioversity International , 2008-2011
  - Released to the international community in December, 2011
  - 2012 – focus on gap analysis for NPGS implementation

Crop Science Registered cultivars, germplasms, genetic stocks, RFLP maplines and parental lines, or ‘most recent registrations’ are searchable. ‘MAIZE GP Accessions’ list 582 GP accessions. Example:

Reg. No.	Name	GRIN Accession Id	Registration Date	Species
GP-1	B49	PI 550443	01-Jan-1971	Zea mays subsp. mays
GP-3	B64	PI 550440	01-Jan-1971	Zea mays subsp. mays
GP-4	B67	PI 550455	01-Jan-1971	Zea mays subsp. mays
GP-5	B69	PI 550456	01-Jan-1971	Zea mays subsp. mays
GP-6	Iowa Elite Line Synthetic No. 1	PI 550457	01-Jan-1971	Zea mays subsp. mays
GP-7	Iowa High Oil Synthetic No. 1	PI 550458	01-Jan-1971	Zea mays subsp. mays
GP-8	Iowa High Oil Synthetic No. 2	PI 550459	01-Jan-1971	Zea mays subsp. mays
GP-9	BSTL	PI 550460	01-Jan-1971	Zea mays subsp. mays

PVP Number	Variety	Grin ID	Status	Date-YMD	Applicant	Qty
9600271	ZS01250	PI 595616	Application Abandoned	1997/12/08	Garst Seed Company	100 sd
9400242	ML606	PI 583774	Certificate Abandoned	2003/08/21	United AgriSeeds, Inc.	100 sd
9300186	CQ702RC	PI 566938	Certificate Expired	2011/11/30	United AgriSeeds, Inc.	100 sd
9300116	PHW53	PI 565112	Certificate Expired	2011/08/31	Pioneer Hi-Bred International, Inc.	25 sd
9300103	PHVJ4	PI 565099	Certificate Expired	2011/08/31	Pioneer Hi-Bred International, Inc.	100 sd
9300049	ICI581	PI 564697	Certificate Expired	2011/08/31	Advanta Technology Limited	100 sd
9300038	LH184	PI 564542	Certificate Expired	2011/08/31	Holden's Foundation Seeds, Inc.	15 sd
9200251	LH224	PI 562381	Certificate Expired	2011/08/31	Holden's Foundation Seeds, Inc.	25 sd
9200250	LH223	PI 562380	Certificate Expired	2011/11/30	Holden's Foundation Seeds, Inc.	25 sd

Sample screen from the GRIN public interface of available lines with expired or abandoned PVP certificates

You can also access a list PVP certificates that will expire within six months

Crop	PVP Number	Variety	Status	Date issued	Expiring
Corn, field	9300108	PHHB9	Certificate Issued	02/28/1994	02/29/2012
Corn, field	9300113	PHN41	Certificate Issued	02/28/1994	02/29/2012
Corn, field	9300114	PHRE1	Certificate Issued	02/28/1994	02/29/2012
Corn, field	9300081	MBWZ	Certificate Issued	03/31/1994	03/31/2012
Corn, field	9300082	AQA3	Certificate Issued	03/31/1994	03/31/2012
Corn, field	9300083	91IFC2	Certificate Issued	03/31/1994	03/31/2012
Corn, field	9300084	2FADB	Certificate Issued	03/31/1994	03/31/2012
Corn, field	9300085	MM501D	Certificate Issued	03/31/1994	03/31/2012

The Global Crop Diversity Trust is an independent international organization which exists to help ensure the conservation and availability of crop diversity for food security worldwide.

It was established through a partnership between the United Nations Food and Agriculture Organization (FAO) and the Consultative Group on International Agricultural Research (CGIAR).

***The 2nd State of the World's Plant Genetic Resources for Food and Agriculture was produced by* FAO, as well as the gaps and needs that remain for setting future priorities.**

The SoWPGR-2 provides the basis for the updating of the *Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture*.

GG Project Goals…The Trust

- **To provide the world's crop genebanks with a powerful, flexible, easy-to-use global plant genetic resource (PGR) information management system that will constitute the keystone for a sustainable, rational, efficient, and effective global network of genebanks to permanently safeguard PGR vital to global food security, and to encourage the use of PGR by researchers, breeders, and farmer-producers.**

GRIN-Global database and interface(s) design:

- Accommodates both commercial and open-source programming tools
- Database-flexible (MySQL, Oracle, MS SQLServer, express, full or enterprise versions)
- Requires no licensing fees for genebank use, enabling institutions with limited IT resources as well as better-supported genebanks, to adopt .
- Deployable on local stand-alone
- Source code will be freely accessible

GRIN-Global System

***GRIN-Global mission*: create a new scalable, version of the GRIN system suitable for use by any interested genebank in the world.**

It has been developed via a joint effort with the Global Crop Diversity Trust, Bioversity International, and the Agricultural Research Service of the USDA.

Replacement of the current GRIN system for NPGS use with the GRIN-Global system is scheduled for 2012 / 2013.

http://www.grin-global.org/index.php/Main_Page

November, 2010 'Train The Trainers Workshop'

Challenges to Utilizing Exotic Maize Genetic Diversity

- Photoperiod
- Agronomics
- Heterotic Pattern
- Inbreeding Depression

- Agronomics
- …..
- Capturing the Positive and Leaving the Negative Behind

FS8A and FS8B were derived from FSHmR (Horner, 1990), a population with good resistance to Race O of Southern Corn Leaf Blight, on the basis of pedigree records while trying to minimize the relationships between them. Tropical sources, accounted for significant proportions of these germplasm releases. The four FS8 accessions have made important contributions to GEM Project enhancement effort s.

Reg. No.	Name	GRIN Accession Id	Registration Date	Species
GP-214	FS8A(S)	PI 536619	01-Jul-1990	Zea mays subsp. mays
GP-215	FS8A(T)	PI 536620	01-Jul-1990	Zea mays subsp. mays
GP-216	FS8B(S)	PI 536621	01-Jul-1990	Zea mays subsp. mays
GP-217	FS8B(T)	PI 536622	01-Jul-1990	Zea mays subsp. mays

From Tracy (1990); “The purpose of this study was to evaluate the potential contributions of five populations: NTZ Mexican Dent, NTZ Cateto, NTZ Caribbean Flint, NTZ Cuzco, and NTZ Coroico to sweet corn improvement. Five pops were crossed to 9 sweet corn inbreds adapted to Wisconsin. The 45 resulting TPXs and appropriate checks were grown at 3 locations in 1986 and 1987. 15 traits were evaluated including yield… All traits varied significantly due to population and inbred effects. The pop x inbred interaction effects were significant for growing degree days (GDD) to midsilk, plant ht, rt ldg, ear mst, yield, kernel depth and width, ear length and width, and number of kernel rows. Mexican Dent TPXs were the highest yielding, averaging 7.59 Mg ha~'. The lowest yielding TPXs were those with Coroico as a parent, averaging 5.43 Mg ha '. Compared to the sweet corn checks, the exotic populations contributed little to decreased stk ldg or rt ldg. The Mexican Dent pop contributed the most positive and least negative effects followed by Caribbean Flint and Cateto. Coroico and Cuzco had little to offer in terms of plant and ear appearance.”

Historic Examples of Successful Capture of Allelic Diversity

The 1971 Crop Science registration of GP-1 (Germplasm Parental Line 1), B14A (Russell et. al.1971) "B14A (REG. No. PL 1) –

Selected from (Cuzco X Early Dent) Selection X B14s and released in 1962. inbred B14A is nearly identical to B14 except that B14A has the gene *~R,pl* obtained frown (Cuzco X Early Dent) Selection, which gives it high resistance to all known biotypes of corn leaf rust, *Puccinia sorghi* Schw., in the United States. Inbred B14 was selected from Iowa Stiff Stalk Synthetic and released in 1953. It has been used extensively in seed production and breeding programs because it contributes outstanding resistance to root and stalk lodging, fast ear drying, and above-average yield. It has good tolerance to the western corn rootworm, *Diabrotica virgifera* LeConte. Maturity classification is early AES900."

An array of tropical germplasm from Latin America and Asia, Maize Amargo, Cuzco, Suwan, Tuxpeno, Southwestern maize landrances, have contributed much to modern germplasm.

Disease resistance is always of concern, and exotic germplasm continues to provide genes for ever-evolving, ever-mobile pathogens.

Southern rust, headsmut, and aflatoxin are of concern in the U.S. while banded leaf sheath disease and maize rough dwarf virus are of concern in Asia for both rice and corn.

Banded leaf sheath suspect – north of Beijing, 2011

Southern rust – causal organism *Puccia polysora* Underw

Southern corn rust was first identified in 1891 on *Tripsacum dactyloides* L. It was validated from herbarium specimens of corn and suggested to have been widespread much earlier in Latin America (Renfro, 1998).

It infects the teosintes (*Zea* spp.), two species of *Erianthus*, and three species of *Tripsacum* (Renfro, 1998), but their role in epidemiology is unclear. It can cause yield losses of 45% or more on susceptible maize germplasm. Tropical germplasm has been utilized to extract a series of (Rp) resistance genes. It is distinct from common and tropical rusts, caused by *P. sorghi* and *Physopella zeae*. Jim Brewbaker has generated a series of tropical lines incorporating southern rust resistance from tropical germplasm, and has worked to reduce their photoperiod sensitivity.

A single dominant gene *Rpp9*, described from PI 186208 (Boesman yellow flint), is used in North America as a source of a chlorotic fleck resistant reaction against *P. polysora*; however, this gene is ineffective in many parts of the world due to virulent isolates. The *Rpp9* gene is located on chromosome 10S about 1.6 cM from the Rp1 region of genes conveying resistance to *P. sorghi*.

Several additional sources of Rpp-resistance map to the same region of 10S as *Rpp9* or they are allelic with *Rpp9* based on resistance of testcross progeny.

In 2008,the first isolates of *P. polysora* virulent on corn lines with the *Rpp9* gene, including PI 186208, were collected in 50 years from Grady County, Georgia. (Dolezal et.al., 2009a). From 2004-2008, ***Rpp9* virulence had occurred in the western hemisphere (e.g., Brazil, Mexico, Nebraska, and Texas), but prior to 2008, uredinia were not observed east of the Mississippi River on corn with the *Rpp9* gene (Dolezal et.al., 2009b).**

Several sources of resistance thought to carry the *Rpp9* gene were resistant when inoculated with a wild-type isolate of *P. polysora* from Illinois, susceptible when subjected to wild type isolates at Waimanalo, Hawaii, but had differential reactions when inoculated with Rpp-virulent isolates from Georgia.

The differential reactions of these lines suggests that genes in addition to *Rpp9* are involved in the southern rust resistance of some of these Rpp-resistant lines and/or that the *Rpp9* gene is a complex region of multiple resistance genes similar to the Rp1 region for common rust resistance (Pataky et.al, 2010).

Recognition of the Skill and Dedication of Many

A few examples of historically well- known, productive intro-gression programs would include those of Everett Gerrish of Cargill, Major Goodman of North Carolina State University, Arnel Hallauer of USDA-ARS and Iowa State University, Wilfredo Salhuana of Pioneer Hi-Bred International, Marcus Zuber of USDA-ARS and Univ. of Missouri-Columbia, and more recently that of the GEM Project and its 65 collaborators (http://www.public.iastate.edu/~usda-gem), and the curators who make these collections available to all of us.

The 1993 Compilation of North American Maize Breeding Programs (Tracy et al., 1993) provides a comprehensive record of the pedigrees of publicly released lines at the time, from which one can deduce the contributions of exotic germplasm to line development.

In 2012, researchers are still trying to understand genetic control of the continuum observed for flowering and/or photoperiod response (Cai et.al., 2012).

Dr. Elmer Heyne - Associated GRIN Records

A quick search of the GRIN public database returns 147 accessions of wheat, oat, and barley associated with Dr. Heyne

Clav 4018 **Avena sativa** L. POACEAE

Developed in: Kansas, United States

Maintained by the National Small Grains Collection.

NPGS received: Oct-1940. Life form: Annual. Improvement status: Breeding material. Reproductive uniformity: Pureline. Form received: Seed. Accession backed up at second site.

Accession names and identifiers: Heyne Dwarf

Source History

- Accession was developed. Kansas, United States.
- Developers: Heyne, E., Kansas State University

Pedigree

Fulghum / Bond

Citations: J. Nielsen. 1977. A collection of cultivars of oats immune or highly resistant to smut. Can J Pl Sci 57:199-212.

CItr 17715

Triticum aestivum subsp. aestivum POACEAE

'Newton'

Developed in: Kansas, United States

Maintained by the National Small Grains Collection. NPGS received: 29-Jul-1977.

Life form: Annual. Improvement status: Cultivar. Reproductive uniformity: Pureline.

Form received: Seed. Accession backed up at second site.

Accession names and identifiers

Newton

Idtype: CULTIVAR.

KS 73112

Idtype: INSTITUTE.

CI 17715

Idtype: OTHER.

Intellectual Property and Material Transfer Agreements

Crop Science Registration

Identifier: CV-601 Crop: WHEAT. Date issued: 01-Jul-1978.

Reference: E.G. Heyne, C.L. Niblett. 1978. Registration of Newton wheat.

Crop Sci 18(4):696. Comment: CV-601.

U.S. Plant Variety Protection **PVP7800100**

Crop: WHEAT, COMMON. Date issued: 01-Mar-1979. Current status

Application of Technology to Identification and Capture of Valuable Allelic Diversity

Phenotyping
Genotyping
    GBS
    Resequencing
Association analysis
GWAS

Bioinformatics

Leveraging information across platforms

Next nine slides courtesy of Maria Cinta Romay and Edward Buckler IV, Cornell University and USDA-ARS

Maize inbred lines at the NCRPIS*: a great public resource to explore maize genetics

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Maize meeting 2012

* PI Station in Ames, IA

Objectives:

- Evaluate the genetic diversity present at the entire USDA maize inbred lines collection
  - Confirm germplasm identity and help with curatorial management decisions
  - Identify additional materials that could be requested to improve collection diversity
- Understand population structure across the genome and subgroups of germplasm
- Evaluate the use of the collection and GBS markers for genome-wide association studies
- Facilitate targeted use of the collection

The germplasm: Ames inbred panel

TOTAL: 2,812 unique taxa (2,711 from the USDA collection in Ames, IA)

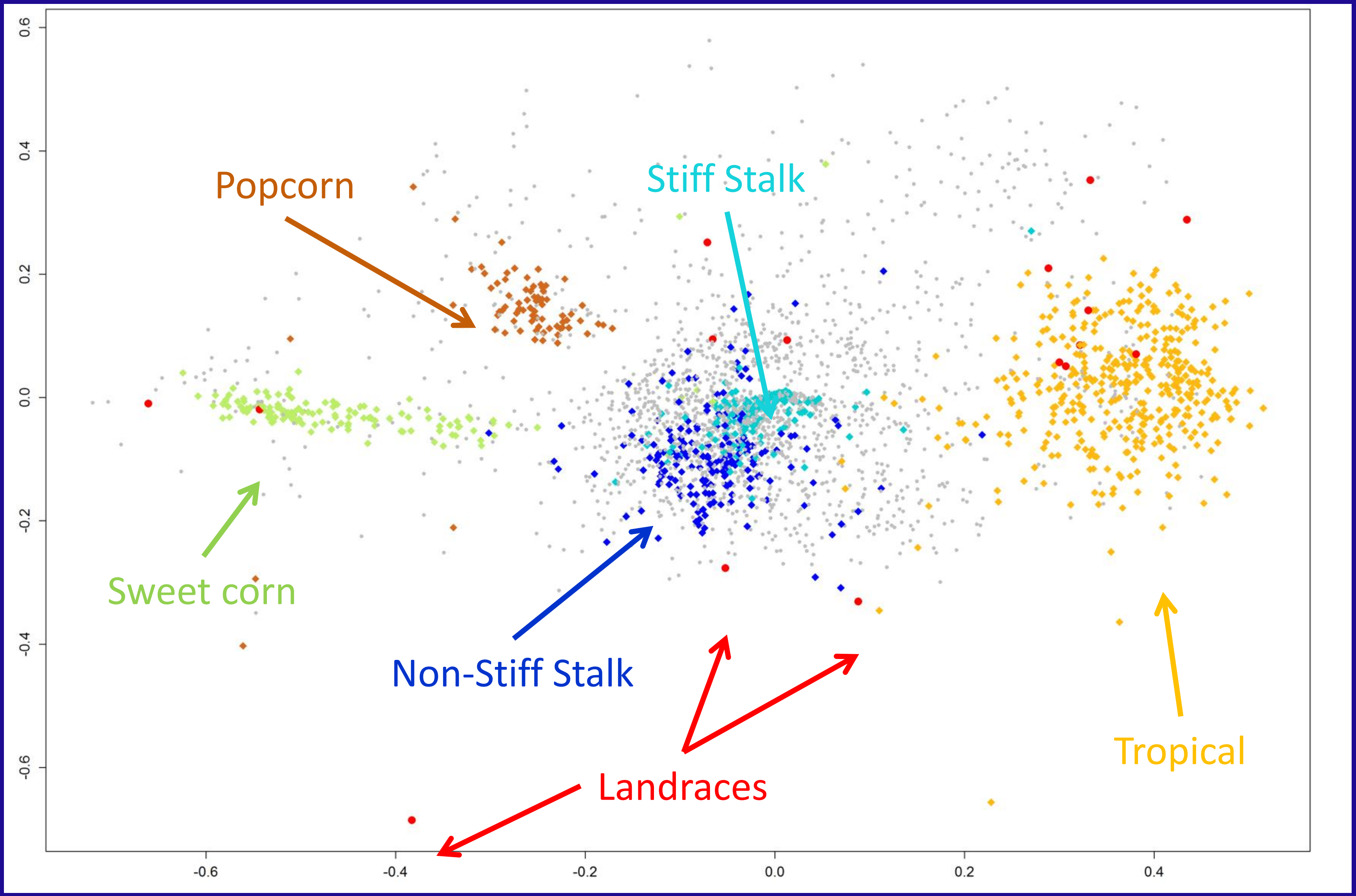
Includes different breeding materials:

- 213 ExPVP
- 212 GEM (GermplasmEnhancement of Maize)
- 179 classified as Stiff Stalk
- 187 classified as Non-Stiff Stalk
- 141 sweet corn
- 80 popcorn
- 402 from tropical origin

Different breeding origins:

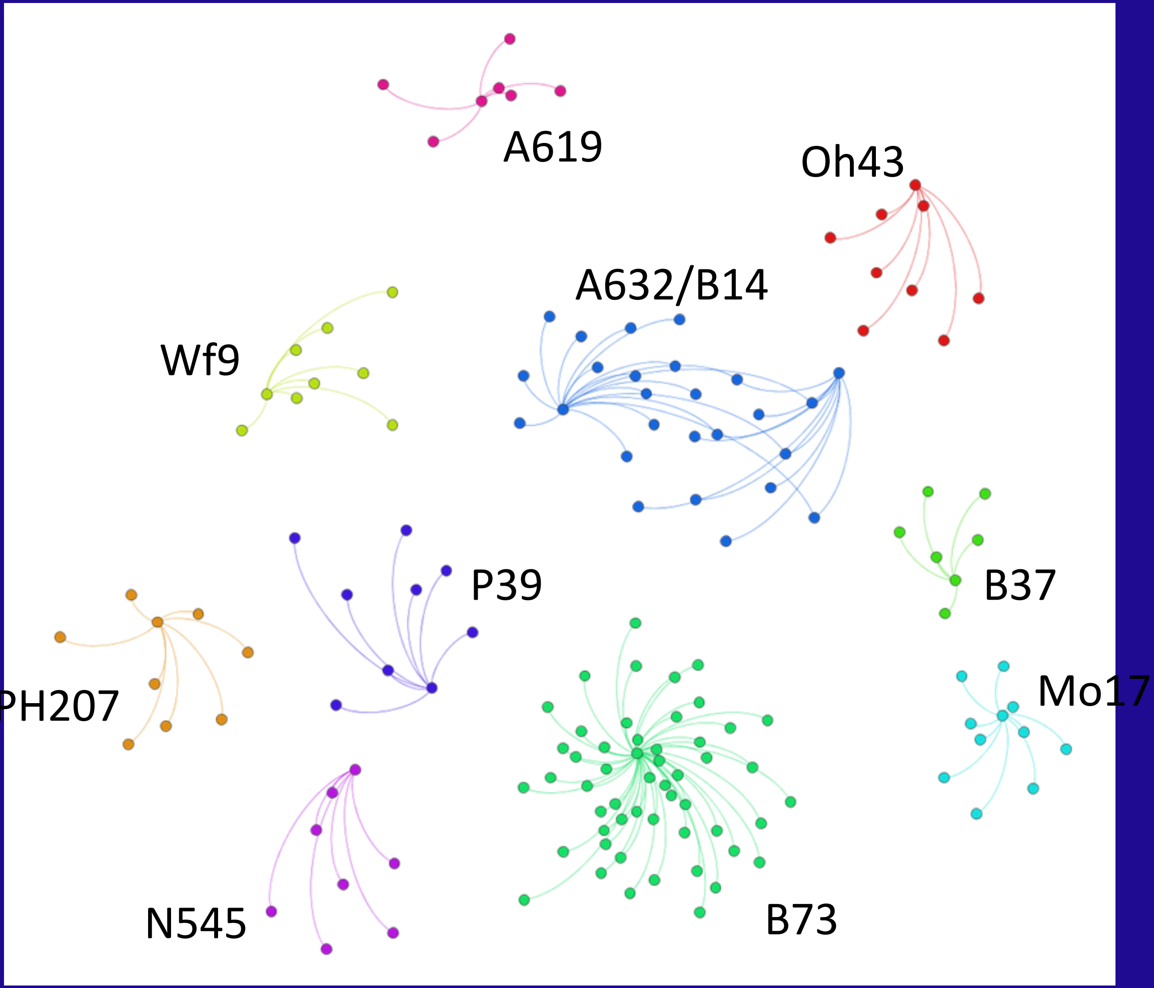
- 31 different countries (USA, Spain, Mexico, Thailand, China, Nigeria, etc.)
- 35 different US states
- Almost a century of breeding efforts

GBS explains the genetic variation among the 2,812 maize inbreds



Principal Coordinate Analysis of the maize inbreds using information from GBS markers

Some historical inbreds create clusters with more than 10 lines

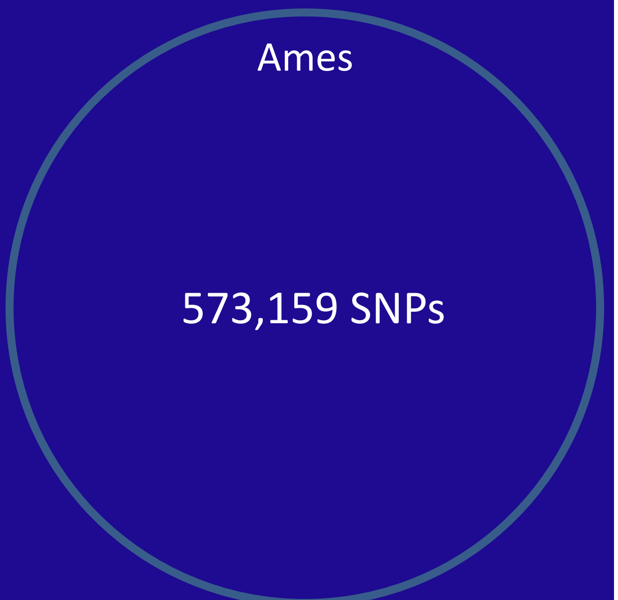


Network of inbreds more than 0.96 IBD

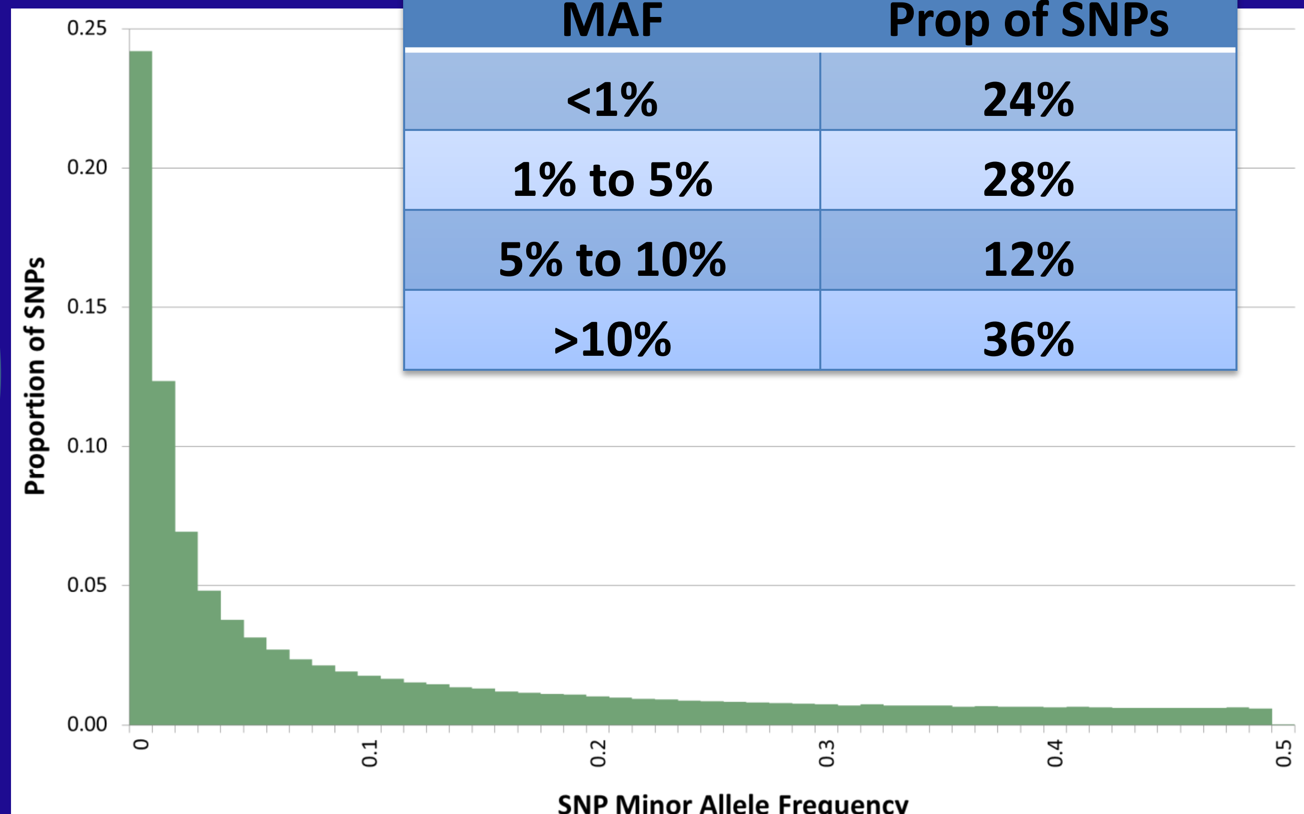
687 lines have at least one BC4-like relation

How are alleles distributed?

Most SNPs are rare in the Ames inbred panel



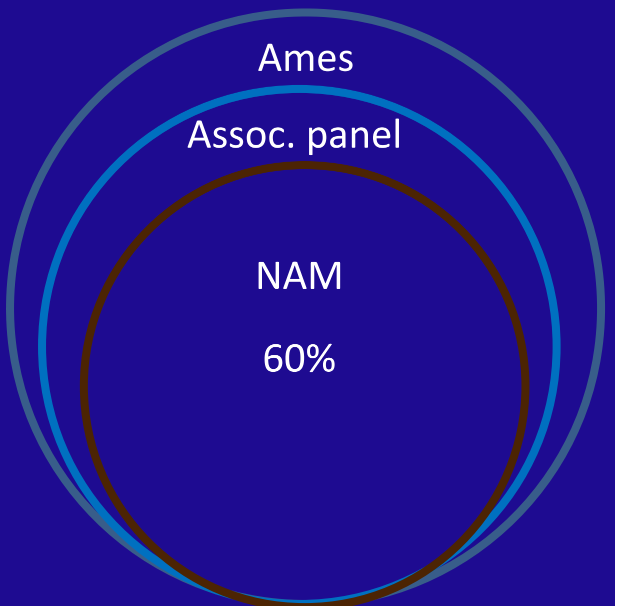
MAF	Prop of SNPs
<1%	24%
1% to 5%	28%
5% to 10%	12%
>10%	36%



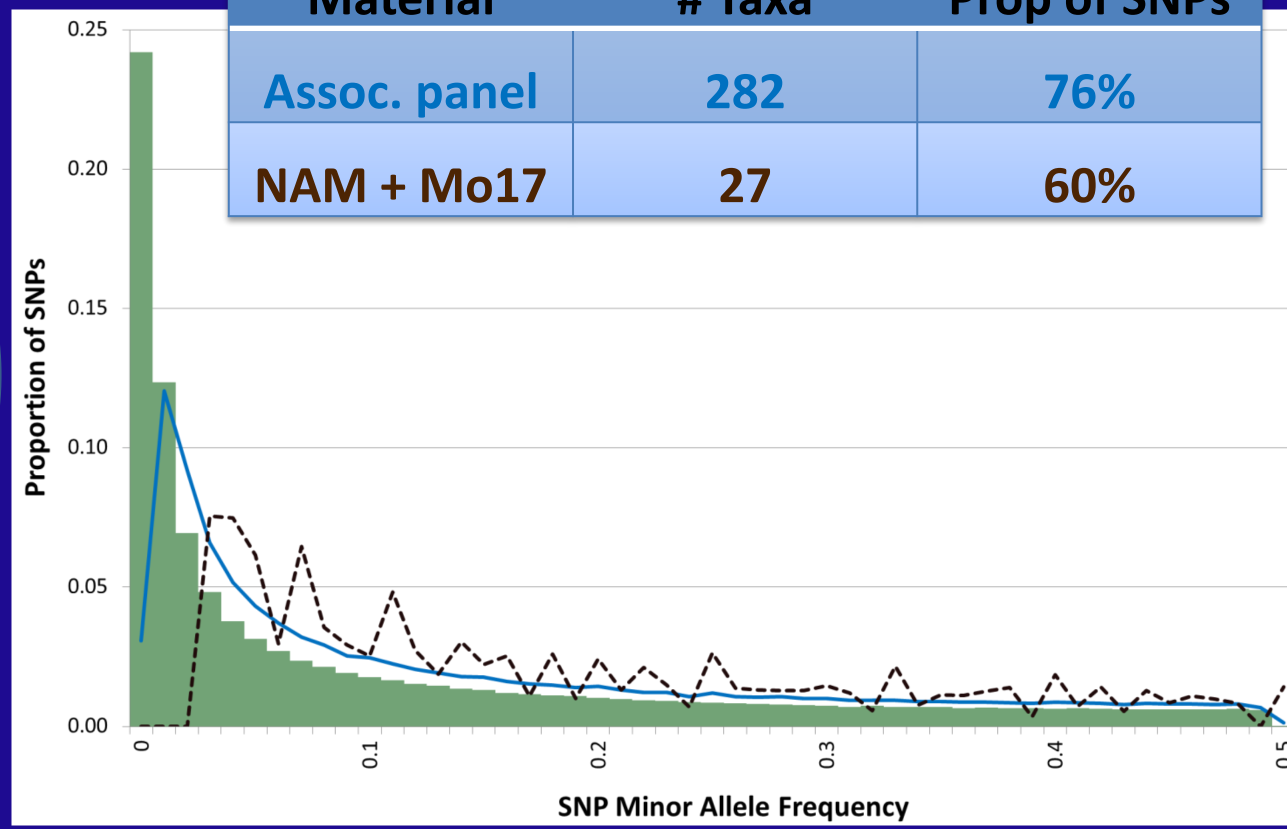
SNP distribution across 2,709 lines

How are alleles distributed?

With a small sample NAM captures over a half of overall diversity



Material	# Taxa	Prop of SNPs
Assoc. panel	282	76%
NAM + Mo17	27	60%

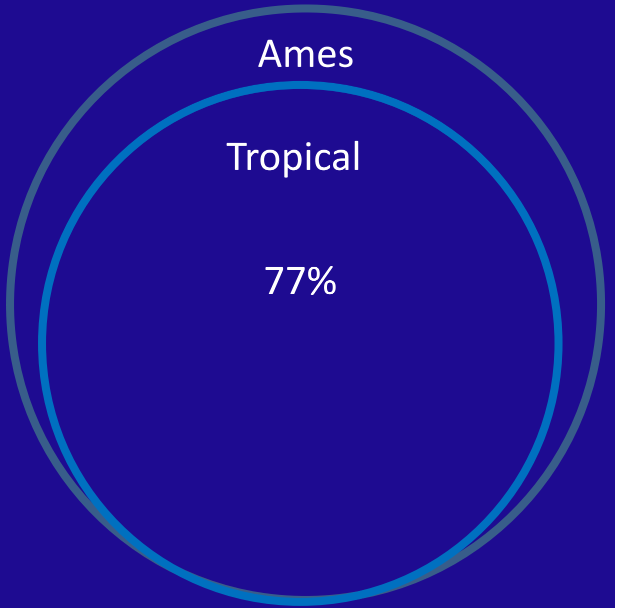


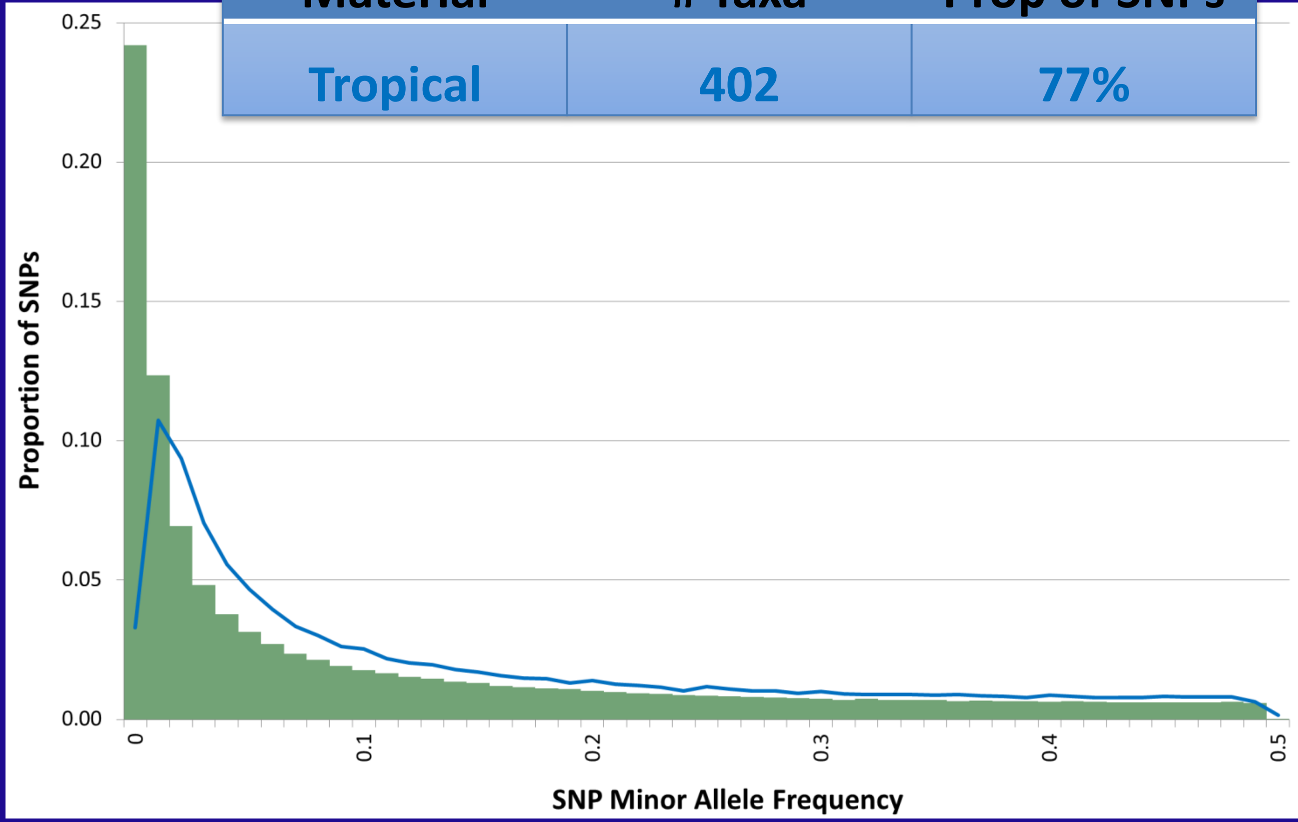
SNP distribution across 2,709 lines vs. 282 lines in the association panel and NAM parents

How are alleles distributed?

Tropical inbreds captures the most allelic diversity

Material	# Taxa	Prop of SNPs
Tropical	402	77%

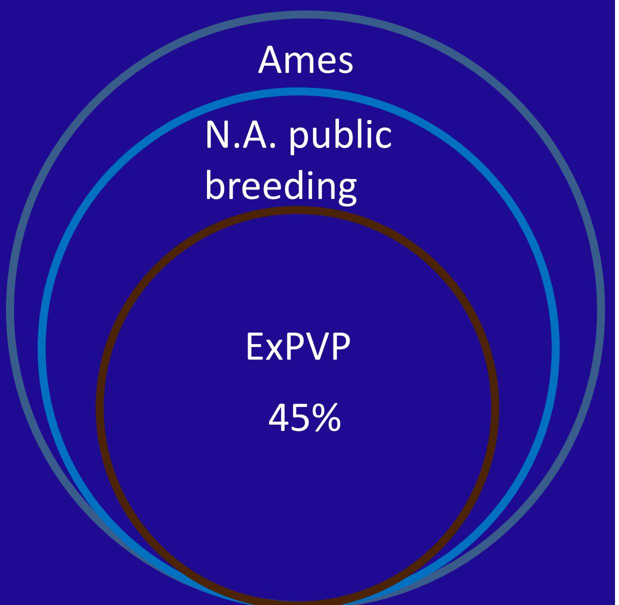




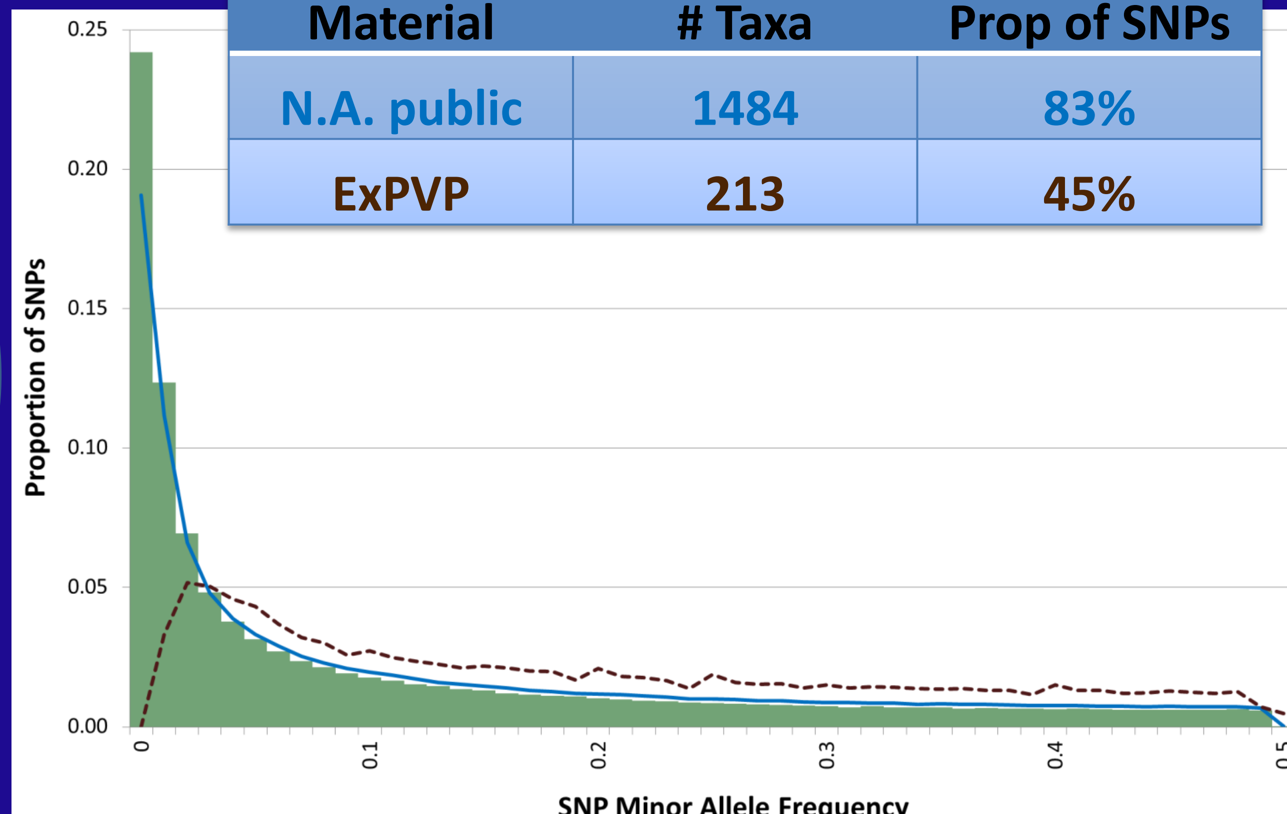
SNP distribution across 2,709 lines vs. 402 lines with tropical origin

How are alleles distributed?

But a modest amount of available diversity has been commercially exploited



Material	# Taxa	Prop of SNPs
N.A. public	1484	83%
ExPVP	213	45%



SNP distribution across 2,709 lines vs. 1484 N.A lines from public breeding programs and 213 ExPVP

Germplasm Enhancement of Maize - Allelic Diversity Project

Mike Blanco, Matt Krakowsky, and Wilfredo Salhuana

Obs field of DH GEM lines in Raleigh, NC - 2010

Use of Doubled Haploid Technology

- Over the past three years, GEM Project personnel embarked on a project to create a set of lines that would be representative of the allelic diversity of all of the races of maize.
- BC1-derived inbred lines are derived either conventionally from tropical accessions with crossed with two expired PVP lines, or by deriving doubled haploid lines from the BC1s in conjunction with Iowa State University's Doubled Haploid Facility (http://www.plantbreeding.iastate.edu/DHF/DHF.htm).
- Two of the first publications from this effort have been submitted and one accepted, . (Brenner et.al 2012) and Smelser et.al.

Allelic Diversity for Cell Wall Digestibility
Brenner et.al., 2012

- Genotypic and phenotypic variation for cell wall digestibility (CWD) of 50 backcross 1 (BC1) doubled haploid (BC1DH) lines developed from 31 exotic races introgressed into ex-PVPs lines PHZ51 and PHB47 was characterized.

- The 50 BC1DH lines and 5 check lines were genotyped with 199 SNP markers distributed across the genome. On average, 11.8% of markers were identified as donor parent alleles, but this is likely an underestimation of donor introgressions, since monomorphic alleles from donor and recurrent parents could not be discriminated, although donor fragments evaluated across BC1DH lines covered 92.9% of the recurrent parent genome.

- **The proportion of donor genome among lines varied from 4 to 42%.**

- **All BC families from PHB47/GORDO [CHH131] had larger proportions of donor parent genome introgressed into the recurrent parent (26% on average).**

- **From the introgressed alleles, on average, 16.6% of donor alleles were different from alleles in the inbred checks; this varied and was not consistent among BC lines sharing the same donor/recurrent parents.**

- **Favorable alleles for cell wall digestibility (CWD) were found among the GEM BC1DH lines.**

Smelser et.al – Haploid Induction and Doubling of Diverse Germplasm

- In 2008 and 2009, 152 populations from 82 races were induced in collaboration with the ISU Doubled Haploid Facility, using Hohenheim induction line RWS X RWK-76.

- Average haploid inductions rates in 2008 and 2009 of 5.9% and 9.3%.

- Doubling rates ranged from 0-24%; a very few races failed to double .

- The 2010 season was much less favourable for reproduction, and severe storms damaged plantings.


NCRPIS

Summary

- ***The inherent value of diverse plant genetic resources is enormous, perhaps not truly estimable.***

- ***Plant genetic resources provide the foundation of our crop improvement and sustainable production systems.***

- ***Demand for maize genetic resources and associated information continues to increase annually. Resources to conserve, maintain, characterize and provide them have not.***

- ***Technological opportunities to exploit and capture useful maize genetic diversity have never been greater – BUT - advanced technologies alone are not enough.***

- ***Genetic prediction alone cannot translate into performance .***

- ***Successful capture of useful genetic diversity comes to those who explore, learn, attempt to understand what unique germplasm offers, and creatively apply their resources to crop improvement in a focused manner.***

- ***R&D is by nature a collaborative endeavor. Future access to diverse genetic resources also depends on our collaborative efforts .***

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